DOCUMENT RESUME

ED 071 460 FL 003 174

AUTHOR	Strevens, Peter
TITLE	Technical, Technological and Scientific English (TTSE).
PUB DATE	Jan 72
NOTE	17p.; Paper presented at the International Association of Teachers of English as a Foreign Language Conference in London, England, January 1972
EDRS PRICE	MF-$0.65 HC-$3.29
DESCRIPTORS	*English (Second Language); *Language Instruction; Language Patterns; *Language Role; *Language Styles; Language Usage; Science Education; *Scientific Concepts; Second Language Learning; Teaching Methods; Technical Education; Thought Processes; Vocabulary; Vocational Education

ABSTRACT

There is a large and growing demand for English language teaching to be provided specifically for the needs of a particular subject, profession, or occupation beyond the approach to English as a general educational and cultural subject. It is possible to isolate and define technical, technological, and scientific English, all with common features of English, but with distinctions in concepts, characteristic thought processes, vocabulary and terminology, and the logical-grammatical devices used to express the concepts. All these elements contribute to the recurrent grammatical patterns evident in a particular type of language. One way to teach specialized English would be in a special purpose course after the student has learned "common core" English in a conventional course. (VM)

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TECHNICAL, TECHNOLOGICAL AND SCIENTIFIC ENGLISH (TTSE)

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IATEFL Conference,
London, January 1972

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TECHNICAL, TECHNOLOGICAL AND SCIENTIFIC ENGLISH (TTSE)[1]

1. Until very recently, the greatest effort in teaching English to speakers of other languages has been concentrated on English as a general educational and cultural subject, taught within the framework of a school system. This kind of English teaching is still of very great importance. However, there now exists in addition to conventional English teaching a large and growing demand for English language teaching to be provided specifically for the needs of a particular subject, profession or occupation; and for this teaching to be carried on largely outside the school system. Within the wide range of vocational uses of English we can identify a group concerned with pure or applied science, at various levels of complexity. This paper outlines the nature of the English used for such purposes, and touches on some of the problems that arise in teaching it.

2. The labels 'scientific English' or 'technical English' are often used, though without being closely defined or distinguished from one another. In fact, it is not so much the features of the English that determine the choice of label, but the purposes for which the English is used. My own preference is for a 3-part distinction, between <u>science</u>, <u>technology</u> and <u>technical services</u>; each of these has a separate function and can be shown to employ language in a different way. At the same time there are a number of features common to all three sub-divisions. Before looking at each of these separately we should consider what they have in common.

FEATURES IN COMMON AND SEPARATE

3. TTSE makes use of the same phonology, the same orthography, and the same grammar as do other uses of English. There is no special accent for talking about science; the spelling is the same; the same pronouns, tenses, word-order etc. are used, and so on. As to grammar, TTSE employs Standard English and it occurs in both spoken and written forms. The vocabulary of TTSE is partly common-core and partly special to itself. In addition to these common features, TTSE alone employs an elaborate range of written symbols, chiefly but not solely those of mathematics, which link in with the extensive use of numbers.

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(1) This paper was given at the Conference of the International Association of Teachers of English as a Foreign Language in London, January 1972. It is based on a course on <u>English for Science and Technology</u> given at the Regional English Language Centre, Singapore, October 1971.

4. Beyond the obvious features of grammar, phonology, graphology and lexis, TTSE is used in order to express a large number of concepts and to conduct a number of intellectual processes. Some of the concepts and processes are shared with English in general, while others are confined to science or even to particular branches of science. Finally, the contexts in which TTSE is used are almost always specific to science, technology or technical work.

GRAMMATICAL AND RHETORICAL FEATURES OF TTSE

5. In pointing out that TTSE makes use of the same grammar as do other uses of English one is merely affirming that 'scientific English is a variety of English'. But in fact the recurrent grammatical patters of TTSE are characteristic and are different from those of other varieties. These patterns are predictable with fair certainty. Although he is not as a rule consciously aware of them, the educated native speaker of English is very sensitive to such grammatical features as: sentence length (i.e. the number of clauses contained in sentences); type and sequence of clauses within a sentence, relative frequency of main and subordinate clauses; order of the subject in relation to the main verb, and the amount of variation in this sequence; number of adjuncts (adverbial and prepositional phrases) and their location initially or finally in the clause; relative frequency of particular verb-forms (e.g. passive or active, tense, aspect, etc.); reference forward or backward in the text; and several others. R. V. White has successfully used in undergraduate teaching a specification of these and other grammatical features in a text, but without specifying the lexis of the text, to elicit an identification of the kind of text it must have been. TTSE texts are fairly easily identifiable in terms of these and other grammatical patterns.

6. It has often been observed, that scientific texts employ verbs in their passive forms to a greater extent than most non-scientific texts. But it has also often been stated, I believe wrongly, that this happens because science is 'impersonal' and therefore it is necessary to use <u>it</u> as a subject instead of <u>I</u>, <u>you</u>, <u>he</u>, <u>she</u>, <u>we</u> or <u>they</u>, or Dr. X. However, an alternative explanation for using the passive is concerned not with a choice between 'personal' or 'impersonal' expressions, but with two facts about the <u>rhetoric</u> of English sentences and the nature of much scientific writing. The organisation of clauses in English is such that <u>initial</u> position for the subject (such as occurs in passive constructions) is normally the strongest.

7. Compare these sentences:

i) The temperature of the solution is maintained at 60°C by a thermostat.

ii) A thermostat maintains the temperature of the solution at 60°C.

In terms of rhetoric, sentence i) is 'about' the temperature of the solution; sentence ii) is 'about' a thermostat. The choice of passive voice for the verb is dictated by the theme of the text at that point, not by notions about personal or impersonal constructions.

CONCEPTS EXPRESSED IN TTSE

8. Certain concepts are common to all advanced and complex thought, no matter what the subject, and these general concepts are expressed in English by the use of items such as ALTHOUGH, BECAUSE, IF, UNLESS, UNTIL, WHENEVER, etc. The scientist who cannot handle items of this kind, together with grammatical features such as subordination, relativisation, co-ordination, etc. in English cannot handle science in English; but he cannot handle any other discipline, either.

9. The importance of these general concepts of advanced thought is that they state the logic - the rhetoric, the argument - of the text, as well as having grammatical consequences. They do not fit into any single grammatical category, and it may be convenient to call them logico-grammatical items. These can be grouped into a number of classes according to the notions they convey. There are approximately 100 items, in about 7 notional classes (see Appendix A); the following examples give only three items in each class, to serve as illustrations:

LINKING AND LOGICAL SEQUENCE OF IDEAS

furthermore, thus, in addition to .....

EXCHANGE AND ACQUISITION

like, similarly, as if .....

CAUSALITY

because, therefore, as a result of .....

OPPOSITION OR CONTRAST

however, nevertheless, in spite of .....

RESTRICTION

except, unless, only if .....

HYPOTHESIS

conclude, refute, suppose .....

ENQUIRY

how big, long, many? etc. with what purpose, to what extent?

10. A second type comprises those concepts which are general to science and technology but are not typically present in non-scientific English. These concepts reflect and convey the philosophy and methodology of science. At this point we touch on a central dilemma in the teaching of English for use by scientists, technologists and technicians. The phrase 'philosophy and methodology of science' conveys to those who have been trained in them a considerable set of beliefs, attitudes, assumptions, values and ethics. To the non-scientist, the extent and nature of these ideas are wholly or partly hidden. And yet when the scientist learns English it is almost always a non-scientist who has the task of teaching it to him. In a brief paper it is impossible to resolve the dilemma. One can only point to its existence and assure the Arts-trained teacher that being a scientist or technologist entails learning a number of habits of thought, that these habits of thought directly affect his use of language, and that the scientist can only function as a scientist if he learns how to use language appropriately to these habits of thought.

11. As a rough approximation, one can summarise the scientist's mental operations thus: the philosophy of science entails concepts of discrimination and description, classification, inter-relation, and explanation, often in that order. (See Appendix B). And each of these concepts in turn implies other concepts, which make up the methodology of science:-

discrimination and description	imply	concepts of identity and difference, processes, states, changes of state, quantification;
classification	implies	concepts of taxonomies, and the co-occurrence of features;
inter-relation	implies	concepts of causality, influence, and interaction;
explanation	implies	concepts of evidence, intuition, hypothesis, experiment, models, theory; etc.

QUANTIFICATION

12. One of these concepts that causes particular difficulties to non-scientist teachers of English is quantification. It is worth noting that scientists need to be able not only to write quantities in mathematical symbols (which forms part of their basic scientific training) but also to understand numbers, algebraic symbols, equations, forumulae etc. when spoken in English, and perhaps even to speak them. There are linguistic problems in verbalising in English an expression like:

$$\sqrt[3]{\frac{5(n-m)^2 + 3(n+m)}{n^2 - 2nm}}$$

Nevertheless the rules for verbalising quantities are conventional and can be taught - once the teacher knows them.

13. All scientific texts, then, will typically make use, as may be appropriate, of the logico-grammatical items and of concepts general to science. In addition, depending on the particular branch of science concerned so particular sub-sets of concepts may be employed. For example, in a work on zoology, a writer may refer to concepts of respiration, reproduction, water-relations, etc; while in a lecture on acoustics a speaker may refer to concepts of frequency, spectrum, bandwidth, phase, etc. These more specific concepts in turn require the use of specialised terms. This is where a consideration of TTSE must turn to questions of vocabulary.

TTSE VOCABULARY AND TERMINOLOGY

14. The vocabulary of TTSE contains words and expressions of three main kinds: (i) the vocabulary of scientific concepts as already outlined; (ii) overlapping with this, a stock of words composed of Greek and Latin roots and affixes, having international acceptance and currency; and (iii) a number of other special scientific and technological coinings.

15. During the past 200 years, scientists working in the Western European tradition have abandoned the former use of Latin as the only appropriate language for scientific discourse. But in accepting other languages - English, French, German, Spanish, Portuguese, Russian, etc. - as being suitable vehicles for writing and talking about science they have nonetheless maintained in use a sub-language of roots, prefixes and suffixes, either borrowed from Classical or Medieval Latin or Greek, or newly-coined with Greek or Latin elements.

Every scientist needs to be familiar with about 50 prefixes (e.g. a-, anti-, auto-, contra-, ex-, intra-, mono-, pre-, syn-, trans-, un-, etc.) about 30 suffixes (e.g. -able, -al, -ic, -ise, -meter, -phage, etc.) and about 100 roots (e.g. bio, calor, geo, tele, dermis, therm, etc.). (See Appendix C.)

16. Scientific and technical terms not using Greek or Latin elements are numerous and new ones are continuously being coined, e.g. peening, milling, count-down, hardware, de-bugging, etc. The learning of special vocabulary seems to be less of a problem to the learner than it may appear to the English language teacher. The scientist has acquired a conceptual framework into which new terminology fits relatively easily, compared with the puzzlement of the Arts-trained teacher when faced with such terms.

JARGON

17. When discussing specialist vocabulary, the word jargon is sometimes used. But increasingly it seems to convey the meaning "I don't understand your technical terms and I dislike it when you use them." Scientists themselves rarely use the word jargon except as a form of apology for using technical terms in the presence of non-scientists, while non-scientists tend to use the word in situations where they feel excluded from understanding what is being said simply because technical terms have been used. The word jargon is thus concerned with the good manners of communication between scientists and non-scientists; it is not a synonym for "scientific vocabulary".(2)

SCIENTIFIC, TECHNOLOGICAL, TECHNICAL

18. It is now possible to explain and justify the distinction made in this paper between three kinds of language use. Each refers to a major portion of scientific activity which uses English in a distinctive way. First we can state the different task of each sub-division:

Science is concerned with understanding, describing and explaining the nature of the universe, (including, of course, Man).

Technology is concerned with how to design, operate and control machines, devices and instruments.

Technical services are concerned with how to construct and maintain the devices invented by technology according to the principles established in science.

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(2) I am indebted to Dr. A. H. King for the reminder that jargon is also used to refer to 'badly-written' science.

19. Not surprisingly, these different tasks lead to different uses of English, which can be described according to the different mixture of features which each displays.

'Scientific English' uses the full range of general and scientific concepts, philosophical as well as methodological; it uses the stock of international scientific terminology based on Greek and Latin roots, the terms of particular branches of science, and other coinings; it assumes familiarity with the symbols and visual conventions of mathematics, but except in the field of mathematics itself it uses less numerical quantification than occurs in technology.

'Technological English' makes less use than does 'Scientific English' of general conceptual language, but it makes full use of special vocabulary and is strong in its use of numerical quantification and mathematical symbols; there is more reference to the concrete and the practical, as contrasted with more use of the abstract and the philosophical in 'Scientific English'.

'Technical English' uses little of the language of general, philosophical or even methodological concepts; the special terminology used relates chiefly to concrete objects and practical processes, rather than to abstractions; quantification is mainly a matter of stating measurements rather than the symbolisation of mathematical relationships; there is a good deal of non-scientific or 'common-core' English interspersed in technical texts.

20. What has been said in the paper about TTSE is far from being an exhaustive description of it. Indeed, by its very nature it is barely conceivable that a complete description of TTSE could ever be made, since it consists of the expression in English of the purposes of the scientist. But the outline may serve to introduce the teacher of English to the nature of the language he is required to teach.

TEACHING TTSE

21. Few teachers of English have a scientific training. The conventional pattern of English teaching in the past has been as a general educational and cultural subject, taught in schools, and for this purpose the training of teachers in the traditions of the humanities has seemed to be appropriate.

It is a consequence of this tradition, however, that teachers of English called upon to teach English for the uses of scientists face special problems. They have to learn something of the habits of thought of the scientist and they have to become aware of the nature of TTSE. Beyond this, they may even have to construct their own teaching materials, since very few suitable textbooks or courses yet exist.

22. Two main alternatives offer themselves as an approach to the teaching of TTSE. The first is to teach TTSE as a special-purpose course after the learner has already learned 'common-core' English in a conventional course. The second is to produce an integrated course, in which the science or technology syllabus is taught with and through the language syllabus.

23. Under certain circumstances, special-purpose TTSE courses, topping-up a basis of common-core English, can be very effective. Such courses can be highly specific; they can often be taught intensively over a short period; since the learners are usually adults with good motivation, they tend to co-operate with the teacher and to work enthusiastically, and to achieve a high rate of success. But there are dangers, too. In some countries, the fact of having followed a long course in English at school (perhaps for 10 or 12 years) is no guarantee that a practical grasp of the common core of English has in fact been acquired, so that a special-purpose course in TTSE has to be preceded by an emergency course in English from scratch. Before special-purpose courses are decided upon, a realistic assessment of the average level of achievement in English must first be made.

24. One particular type of special-purpose course must be mentioned: it is sometimes the case that scientists or technologists need to acquire a reading-only knowledge of English (or another foreign language), in their own branch of science, with no requirement to understand the spoken language, or to speak it. Such restricted aims permit the course-designer to dispense with large components of conventional language teaching courses (particularly the whole of teaching the spoken language) and therefore to reach the target more quickly. A restricted aim can also be more accurately defined than can the aims of full-scale language teaching. Since the scientist is normally an intelligent, sophisticated learner, who is virtually always a volunteer and not a conscript, the circumstances of teaching reading-only courses for scientists are very favourable indeed: progress is usually rapid and success rates are high.

25. The integrated course, in which English is taught by and through science, seems in principle to be the most economical and satisfactory approach, not least because the teacher can devote the whole of the teaching time to activities that are relevant to the eventual aims of the learner. This is in contrast to the most frequently adopted approach, where the future scientist spends a great deal of time on Arts-oriented language work in his basic course before he starts his final special-purpose TTSE course.

26. If integrated courses are theoretically more efficient in learning and teaching time, they are also extremely difficult to design. The conventional course, with its orientation towards general educational, cultural and usually literary activities, has a long history. Fifty years of intense professional activity has led to the emergence of a range of syllabuses, drills and exercises, aural and visual aids, and tests and examinations. Although these are far from ideal, at least they exist; they provide the course-writer with a vast mine of experience out of which he can develop new materials for particular purposes. But the integrated course for TTSE has almost no history, so that those who are currently engaged in producing such courses are dependent on their own resources. What is more, the integrated course requires that not only the English teaching but also the science teaching should be impeccable, and this usually requires close collaboration between writers from the two different specialities. Several such collaborations are at present under way, including for example the work of Professor Ewer in Chile, and the Singapore Primary Pilot Project in English, Science and Mathematics.

27. What the English teaching profession needs most acutely in the coming years is a large number of publications dealing with all aspects of TTSE, and the sharing of experience in trying various techniques and approaches. There is no doubt that the demand for TTSE is going to increase. It offers a challenge to the teaching profession, but one which most teachers will find it exciting to meet.

Peter Strevens
University of Essex
January 1972

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APPENDIX A.

SOME CLASSES OF LOGICO-GRAMMATICAL ITEMS.

NOTE: These categories are 'notional'; they are not presented in order of descending importance; the categories and lists are not exhaustive.

LINKING AND LOGICAL SEQUENCE OF IDEAS

and, also, besides, furthermore, moreover, simultaneously, thus, too;
apart from, as well as, in addition to.

PARAPHRASE AND APPOSITION

like, similarly;
as if, in the same way, in like manner.

CAUSALITY

accordingly, as, because, consequently, hence, once (something has occurred), since, therefore, until, whenever;
as long as, as a result of, by means of, due to, for the purpose of, in order to, it follows that, on account of, owing to;
necessary and sufficient condition.

OPPOSITION OR CONTRAST

alternatively, although, but, if, however, nevertheless, notwithstanding, otherwise, whereas, yet;
even though, in spite of, irrespective of, on the other hand;
necessary but not sufficient condition.

RESTRICTION

except, impossible, occasionally, only, trivial, uncertain, unless;
only if, if and only if, only when.

HYPOTHESIS

conclude, confirm, consider, deduce, imagine, infer, invalidate, refute, suppose, theoretically, validate;
in principle, it follows, it would seem that .....

ENQUIRY

how big? how long? how many? ..... etc;
what? when? which? who? why? how? with what purpose? to what end? to what extent?

APPENDIX B.

CONCEPTS IN THE PHILOSOPHY AND METHODOLOGY OF SCIENCE

Philosophical Concepts	Methodological Concepts
DISCRIMINATION AND DESCRIPTION	IDENTITY AND DIFFERENCE CHARACTERISTICS, QUALITIES, FEATURES PROCESSES STATES AND CHANGES OF STATE QUANTIFICATION
CLASSIFICATION	TAXONOMIES CO-OCCURRENCE OF FEATURES DISTRIBUTION COMPREHENSIVENESS
INTER-RELATIONSHIP	CAUSALITY INFLUENCE INTERACTION
EXPLANATION	EVIDENCE INTUITION HYPOTHESIS EXPERIMENT MODELS THEORY

APPENDIX C.

Some prefixes, roots and suffixes of Greek and Latin origins, with examples and approximate "meanings"

1. PREFIXES

a-	atypical	a = not
ab-	abnormal	ab = away from
ad-	adhesion	ad = to, towards
anti-	antiseptic	anti = against
ante-	ante-natal	ante = before (in time)
auto-	automotive	auto = from within itself
bi-	biennial	bi = two
co-	cohesion	co = with

N.B. co- has other forms:-

con- as in connect
com- as in communicate
cor- as in correlate
col- as in collaborate

contra-	contra-rotation	contra = opposite
de-	defuse	de = take away, undo
dia-	diathermy	dia = through
dis-	dismember	dis = undo, un-make
dys	dystrophy	dys = out of order, functioning badly
ex-	extract	ex = away from, out of (or formerly)
extra-	extra-sensory	extra = outside
in- (a)	inject, inflame, etc.	in = (a) into
in- (b)	inoffensive, incapable	in = (b) not

N.B. in- has other forms:-

il- as in illogical
im- as in immovable
ir- as in irregular

inter-	international	inter = from one to another
intra-	intra-uterine	intra = within
macro-	macro-economics	macro = relatively large
micro-	microwave	micro = relatively small
mono-	monotonous	mono = single
non-	non-toxic	non = not
poly-	polyvalent	poly = many
post-	postpone	post = later
pre-	prehistoric	pre = before

re-	re-cycle	re = again
sub-	sub-zero	sub = below
super-	superficial	super = upon, above
syn-	synthesis	syn = together

N.B. syn- has other forms:-

syl- as in syllogism)
sym- as in symmetrical)

trans-	transmission	trans = across, from place to place
un-	unstable	un = not
uni-	unitary	uni = single

2. ROOTS

(a) Examples where the root is word-initial

bio-	biology, biotic	bio = life
calor-	calorific	calor = heat
chron-	chronological	chron = time
cycl-	cyclic	cycl = repeating
geo-	geophysical	geo = the Earth
magni-	magnifying	magni = large in size
meteo-	meteorology	meteo = the atmosphere
tele-	telemetry	tele = at a distance
zoo-	zoology	zoo = life

(b) Examples where the root is non-initial

-derm	epidermis	derm = skin
-gon	polygonal	gon = angle, corner
-ion	thermionic	ion = electrical particle
-lumen, lumin	illuminate	lumen = light
-mini	diminish	mini = small
-therm	diathermy	therm = heat
-tox	intoxicate	tox = poison

3. SUFFIXES

-able) -ible)	intractable inexhaustible	-able) -ible)	= capable of having something done to it
-al	oral	-al	= an adjective
-ate	vibrate	-ate	= to carry out a process or action
-ation	vibration	-ation	= the process of doing something
-ator	vibrator	-ator	= the object or person carrying out a process or action
-ic	electric	-ic	= having a particular quality
-ise (or US -ize)	computerise	-ise	= to apply a process or bring about a particular change
-logy	psephology	-logy	= the study of a particular field of knowledge
-meter	calorimeter	-meter	= measuring device

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